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How Livestock Production in Eastern Nebraska May Affect Water Nitrate

Concentrations in Platte River

An Undergraduate Thesis

By

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Presented to

The Environmental Studies Program at the University of Nebraska-Lincoln

In Partial Fulfillment of Requirements

For the Degree of Bachelor of Science/Arts

Major: Environmental Studies

Emphasis Area: Natural Resources

Thesis Advisor: Name: Daniel Snow

Thesis Reader: Name: Christine Haney

Lincoln, Nebraska

Date: 12/1/17

Introduction & Objective

The Platte River is one of the largest rivers in Nebraska and serves as a valuable water source to cities along its watershed. Water is essential for both human life and social and economic development. The human body cannot survive without water for more than 3 days, and many industries require water to function. At a regional scale, the total amount of water is relatively constant, which means if some water sources were contaminated there will be less water available to use.

Recent news reports indicate that Costco is planning on build a chicken processing factory in Fremont, and some local residents are not welcoming to the idea since they are concerned the water quality in this region will be negatively impacted.

Fremont is a city in Nebraska located near the Platte River. Based on information from a conversation with Mr. Tim Golden, he mentioned that the chicken processing plant could be a large potential source of nitrate to their water if the chicken waste is not properly managed. Mayor Getzschman and the Fremont City Council also stated “There are serious human health and environmental concerns associated with large poultry processing plants” (*The Johns Hopkins Center for a Livable Future*).

Nitrate water contamination is a well-known and well researched problem. It is one of the most common inorganic contaminants found in surface and ground water. Despite the large number of studies conducted there is still no long-term permanent solution for nitrate contamination of water.

Nitrate (NO_3) is a polyatomic ion composed of three oxygen atom and one nitrogen atom. It is a colorless, odorless and tasteless chemical compound. Both soil

particles and nitrate particles are negative charged, which means they will not bind to one another, and nitrate is easily washed off by water flow and transported into water sources. Many forms of nitrate can be found, this thesis focuses on nitrate as nitrogen ($\text{NO}_3\text{-N}$), which refers to the content of nitrogen (N) in solution due to nitrates.

The regulatory definition of nitrate contamination in drinking water is nitrate-N ($\text{NO}_3\text{-N}$) concentrations above 10mg/L (*nitrate and nitrite in drinking water*). This concentration is equivalent to 45 mg of nitrate per liter of water. Water containing nitrate above this level is considered unsafe to drink.

When water is contaminated by excess amounts of nitrate, using it as drinking water raises health risk to the human body. Blue baby syndrome is a disease characterized by an infant's inability to carry sufficient oxygen to support their lives, trigger blue coloration on skin (see Picture 1) and often is fatal. The most common cause of blue baby syndrome is by drinking nitrate-contaminated water. Adults that consume nitrate contaminated water have higher chance to get cancer. Congenital malformation may also occur by drinking water containing excess amounts of nitrate (*NITRATES, BLUE BABY SYNDROME, AND DRINKING WATER*).



(Picture 1)

It is reasonable for residents of Fremont to have a serious concern about water contamination. No one wants to put their health at risk when drinking water. Nitrate contamination is not a problem that only exists in Nebraska, but it is occurring around the world; it is significant to acquire knowledge and experience through the thesis studying.

Since the construction of a chicken process factory in Fremont has not started, the thesis looks at places that already have large scale livestock production for further studying in order to verify if the concern from residents in Fremont is necessary.

Elkhorn River and Shell Creek are tributaries draining into the Platte River, and both watersheds have large-scale livestock production. These two watersheds were chose for the thesis studying, and the objective of the thesis is to determine whether nitrate concentration in the Platte River is affected by nitrogen from livestock manure in Elkhorn River and Shell Creek watershed. The hypothesis for this objective is: the livestock manure from Elkhorn River and Shell Creek watershed will affect water nitrate concentration in Platte River.

Methods

This thesis is based on literature review, and used information from publically available sources. No field sampling or experiments were required. Data was downloaded and transformed to show historical changes and modeled by using linear regression. Other statistical methods such as line charts and bar charts demonstrate the change of data. But the data point for each studying station is not at the same time,

and data points in some stations were missing, using line chart or bar chart may not be able to create a continuous graph. Scatter plot graphs can be used for discontinuous data, and by inserting a linear trend line, it indicates the approximately trend of the change of data.

To calculate the historical record of nitrogen production in the Elkhorn River and Shell Creek, the data of historical cattle and swine production was collected from the USDA National Agricultural Service. Data of poultry production in both watersheds are not present, only cattle and swine were chosen for this study. And since the data of swine production in Shell Creek after 2000 was missing, the assumption of swine production at Shell Creek from 2000 to 2015 was estimated as the same as the production record in 1995. Barbara C. Ruddy's report (see Picture 2) was used to convert livestock population to nitrogen excretion.

Table 3. Estimates of the nitrogen and phosphorus content in livestock manure (modified from Goolsby and others, 1999).

Livestock group	Nutrient content of manure (kilograms per day per animal)		Life cycle (number of days)
	Nitrogen	Phosphorus	
Milk cows	0.204	0.032	365
Beef cattle	0.150	0.053	365
Steers	0.150	0.048	365
Heifers	0.141	0.018	365
Slaughter cattle	0.104	0.034	170
Hogs and pigs ¹	0.027	0.012	365
Chickens and hens ¹	0.0015	0.0006	365
Pullets and broilers ¹	0.0010	0.0003	365
Tom turkeys	0.0054	0.0020	133
Hen turkeys	0.0034	0.0013	112 or 365
Sheep and lambs ¹	0.023	0.004	365
Horses and ponies	0.127	0.022	365

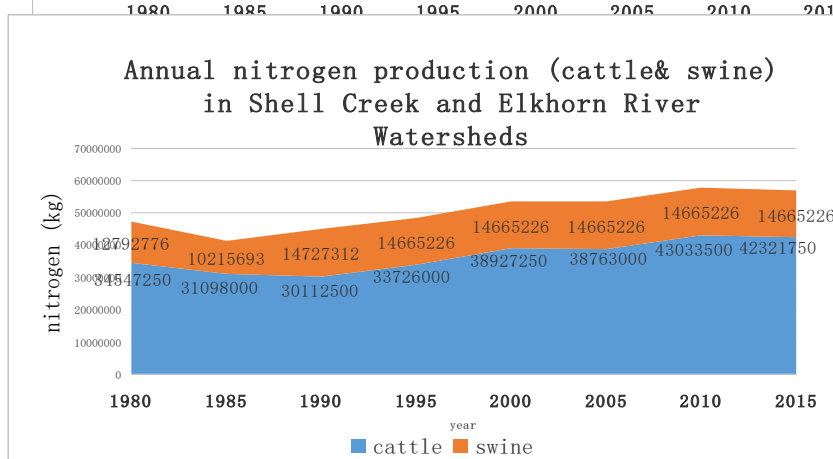
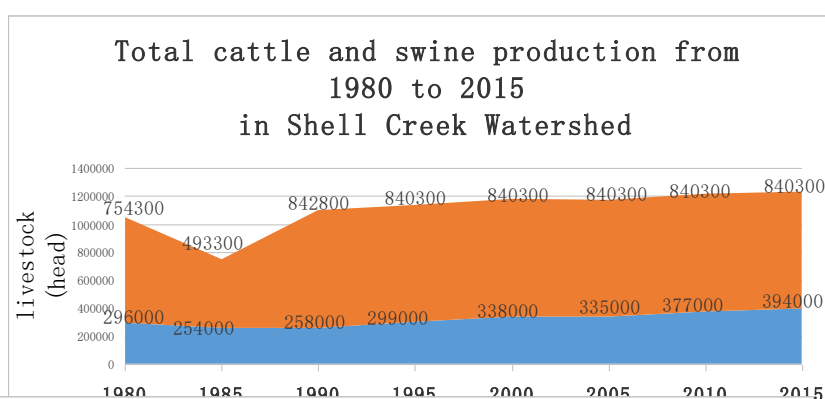
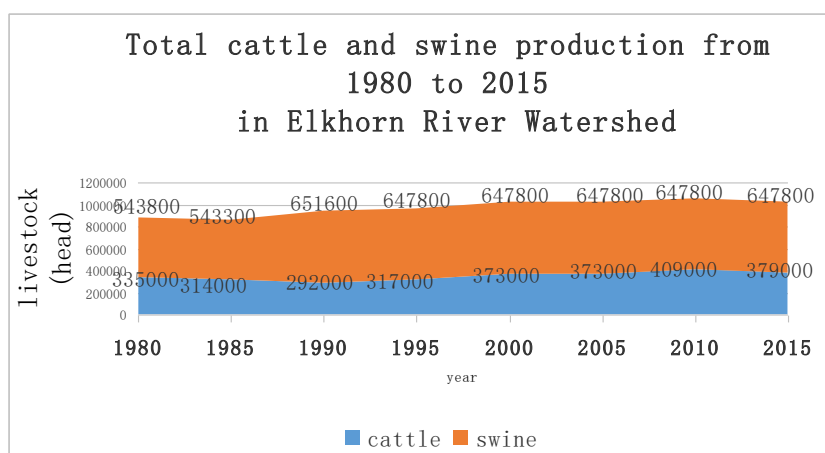
¹ Animals in these groups have a life cycle shorter than one year, but year-end inventories are assumed representative of year-round population.

(Picture 2)

The historical record of nitrogen production in Shell Creek and Elkhorn River can be calculated by the following formula:

(cattle production* cattle N production/day+ swine production* swine N production/day)*365 days

Results

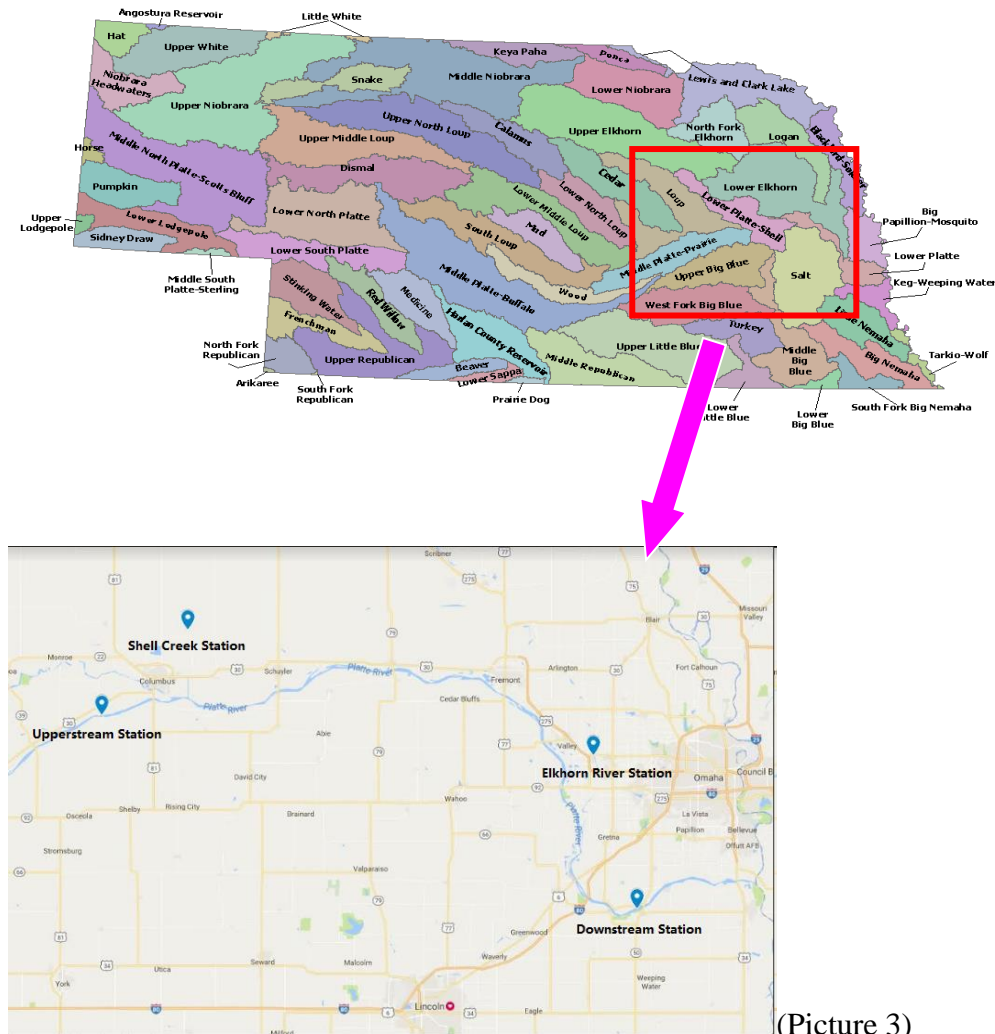


The result of these calculations indicate that the amount of nitrogen potentially contributed from livestock manure increased from 47000 tons in 1980 to 57000 tons in 2015. The rate of increase is 17%.

Gauging stations from Platte River, Elkhorn River and Shell Creek were selected for data collection (see Picture 3). The stations on Shell Creek and Elkhorn River are

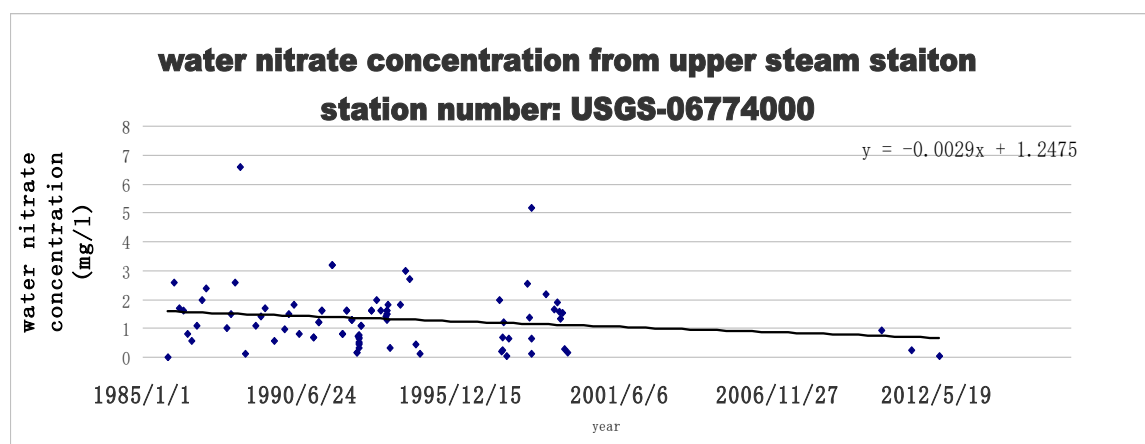
last stream stations on the watershed, which were used to determine the final water nitrate concentration from both watersheds.

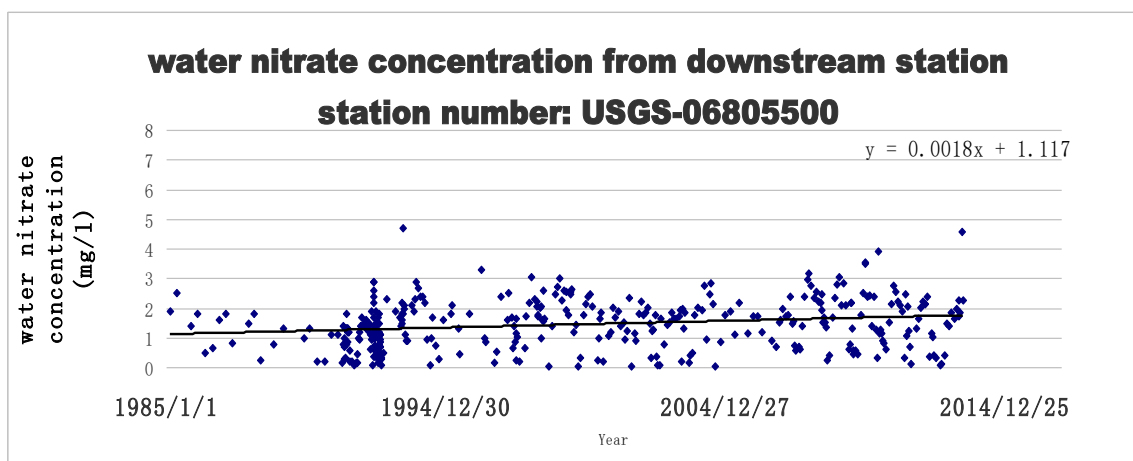
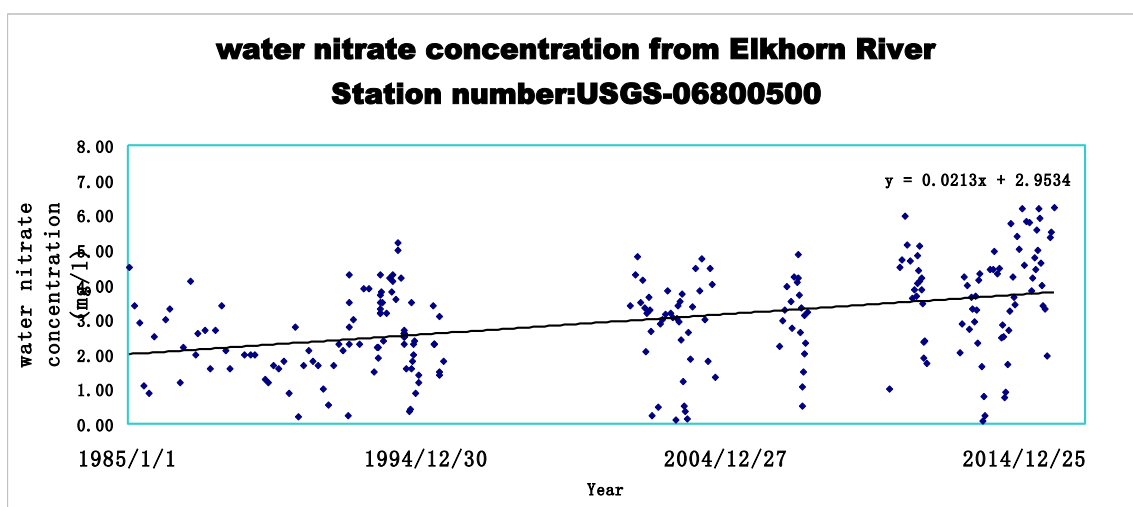
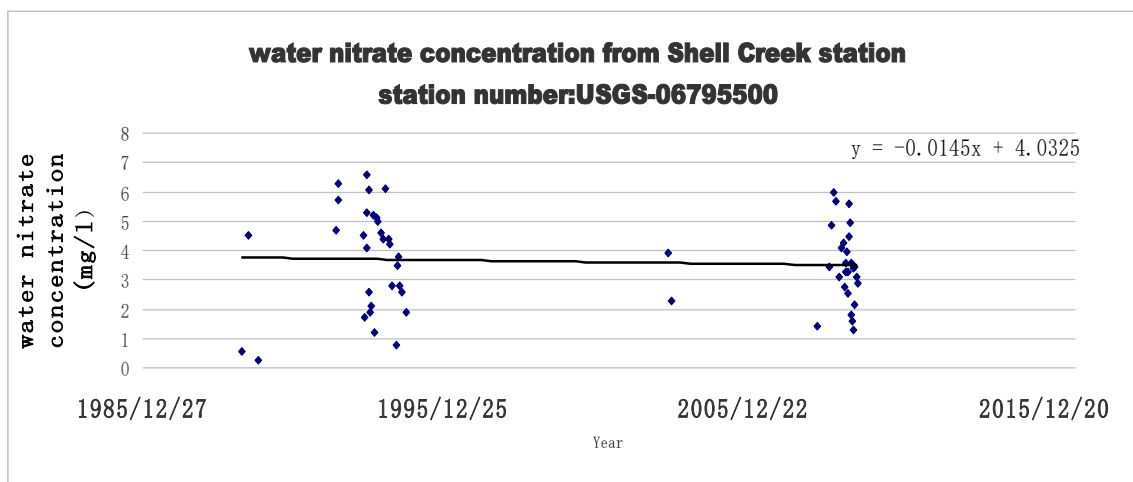
Nebraska 8 Digit Hydrologic Units



(Picture 3)

Historical water nitrate concentration data was collected from the USGS website, and graphed by linear regression to indicate the change of water nitrate concentration:





The data from Upstream and Downstream station indicated a historical increase of water nitrate concentration in the Platte River. The historical change of water nitrate concentration in Elkhorn River is increasing. Compared with data from other stations, the data point for Shell Creek is insufficient to prove a significant change of nitrate concentration, but the trend line shows the water nitrate concentration in Shell Creek is stable or slowly decreasing.

Discussion

Based on a comparison of the data from USGS and USDA, the increase of livestock production in Shell Creek Watershed did not seem to be correlated to the change of the nitrate concentration. This result can be caused by change of livestock manure management. Since animal manure is one of the major sources of nitrate in water, livestock owners are noticing this issue and perform different methods to reduce the nitrate in manure discharge into water (*Poisoned Waters.*). This could be the reason that the increase of livestock production near the Shell Creek Watershed did not affect the local water nitrate concentration.

The data from Upstream Station and Downstream Station show the water nitrate concentration is lower than 10mg/L. But since the water in Platte River is supplied by ground water with high concentration of nitrate (possibly above 20mg/L), the low concentration of water nitrate in the Platte River is above historical levels and is clearly increasing in eastern Nebraska possibly as a result of tributary nitrate inputs.

The conversation with Dr Dave Gosselin had a potential assumption: the organisms living in river bed are using the nitrate in water as nutrition, and they consumed most of the nitrate in the water and have an impact on the concentration of water nitrate in the Platte River.

From data collected in all stations, the combined nitrate input from Shell Creek and Elkhorn River seems to affect the nitrate concentration in the downstream gauging station of Platte River. In this case, the hypothesis is accepted. But it is also notable that the source of increasing $\text{NO}_3\text{-N}$ in Platte River is not only from livestock production in tributaries areas, but also may be from land applied animal manure and increased application of commercial fertilizer to crops as well as urban fertilizer use.

Conclusion

By collecting and comparing data from 4 gauging stations in the Platte River and two tributaries, the change of livestock production from Platte River tributaries watersheds can affect the water nitrate concentration of main stream of Platte River. With the appropriate management of animal waste, the increase of total livestock production will have less of an impact on water nitrate concentration.

In order to lower the health risk caused by nitrate-contaminated water, several methods could be applied and are listed below:

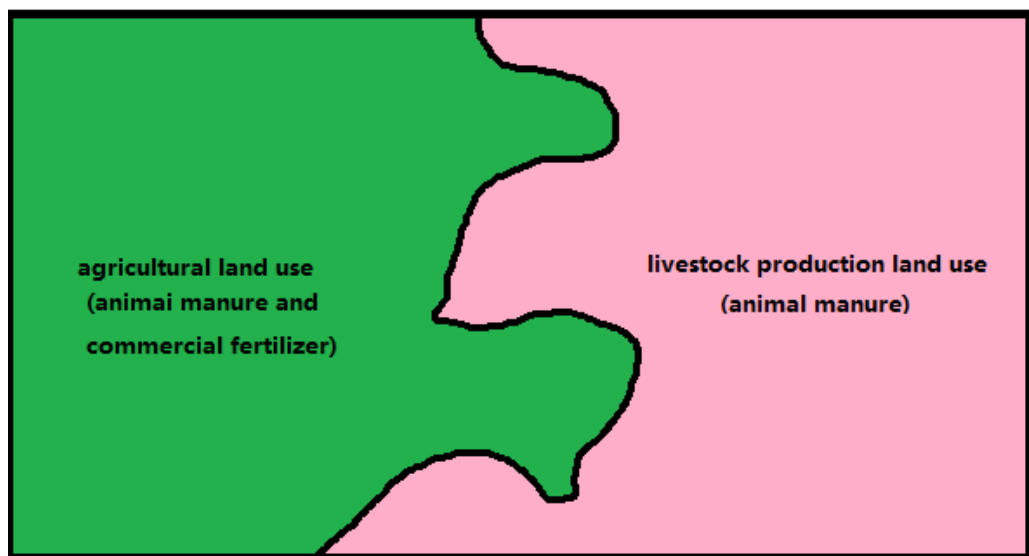
- installing water treatment devices
- making connection to municipal water supplies
- building news well or using bottle water

People also need to be aware that animal manure is not the only source of nitrate in water; other factors are possibly affecting the change of nitrate concentration in surface water.

Future Study

This thesis has much room for improvement and raises many additional questions. By studying local regulation of livestock production in this area, it could give the regulation of livestock manure management and use to predict the discharge of nitrate from it. This method can make the data of nitrate discharge in water more precise.

The land use in Elkhorn River and Shell Creek can be studied to improve data accuracy.



Farmers could use both animal manure and commercial fertilizer for fertilization. The nitrate concentration in studied areas could also be affected by the use of commercial fertilizer, which could accuracy of results. If the further studying could have the information of the percentage of land use, the use of commercial fertilizer

can be calculated and synthesis into data integration, and greatly improve the precision of the result.

References

- N. Beaudet, MS, CIH; A. Otter, DNP, ARNP; C. Karr, MD, PhD; A. Perkins, BA; S. Sathyanarayana, MD, MPH. "NITRATES, BLUE BABY SYNDROME, AND DRINKING WATER: A Factsheet for Families"
- "nitrate and nitrite in drinking water". Washington, D,C, National Academy Press, 1995
- "Poisoned Waters." PBS, Public Broadcasting Service,www.pbs.org/wgbh/frontline/film/poisonedwaters/.
- Ruddy, C. Barbara, Lorenz, David L. *County-Level Estimates of Nutrient Inputs to the Land Surface of the Conterminous United States, 1982–2001*
- *The Johns Hopkins Center for a Livable Future Bloomberg School of Public Health 615 North Wolfe Street, W7010 Baltimore, MD 21205 September 19, 2016 Mayor Getzschman and Fremont City Council 400 E. Military Ave. Fremont, NE 68025*
- *USGS Current Conditions for USGS 06805570 Platte River at La Platte, Nebr., waterdata.usgs.gov/ne/nwis/uv/?site_no=06805570&PARAMeter_cd=00065%2C00060.*
- *USGS Current Conditions for USGS 06795500 Shell Creek near Columbus, Nebr., waterdata.usgs.gov/usa/nwis/uv/?site_no=06795500.*
- *USGS Current Conditions for USGS 06800500 Elkhorn River at Waterloo, Nebr., waterdata.usgs.gov/usa/nwis/uv/?site_no=06800500*
- *,USGS Current Conditions for USGS 06805500 Platte River at Louisville, Nebr., waterdata.usgs.gov/usa/nwis/uv/?site_no=06805500.*
- *USDA/NASS QuickStats Ad-Hoc Query Tool, quickstats.nass.usda.gov/results/770BC5BA-3A22-3FD5-81DF-63CD8545796C.*
- *Picture 1: Blue Baby Syndrome (Infantile Methemoglobinemia). (2011, September 02). Retrieved December 01, 2017, from <https://thedarkpark.wordpress.com/2011/09/02/blue-baby-syndrome-infantile-methemoglobinemia/>*